Crested wheatgrass control and monitoring
Benton Lake Refuge

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Introduction

Crested wheatgrass (*Agropyron cristatum*) became prevalent in the United States in the 1930s after being introduced from the Russian and Siberian steppe habitats (Zlatnik 1999). Crested wheatgrass (CWG) was planted on Benton Lake refuge at least 30 years ago, presumably to stabilize the soil where it had been disturbed in the process of building refuge roads, and possibly burying utility lines.

Benton Lake refuge was established as “a refuge and breeding ground for birds” and CWG can negatively impact the resource value of the refuge. For example, chestnut-collared longspurs, the most common grassland breeding passerine on the refuge, can experience decreased fitness in CWG dominated areas. In northeast Montana, chestnut-collared longspurs nesting in CWG stands had 17% lower nest-survival, slower nestling growth and smaller final nestling mass than longspurs nesting in native grassland (Lloyd and Martin 2005). Furthermore, in areas of the refuge where CWG has become dominant, the total diversity of plants is significantly reduced (Stutzman 2002).

Since CWG was initially planted on the refuge, the CWG has slowly been invading the adjacent native prairie on the refuge. There are approximately 420 acres of CWG on Benton Lake refuge where it forms a monotypic stand greater than 0.25ha (0.6 ac) (Figure 1) and thousands of individual plants that have invaded the adjacent native prairie. We will need address the two types of CWG invasions on the refuge, established stands and individual pioneers, with two different strategies.

Pioneers

Crested wheatgrass plants that have successfully established away from the larger, monotypic stands are the highest concern for protecting the integrity of our native prairie (van Ness, pers. Comm.). These plants are interspersed with native grasses, which are almost exclusively cool season plants that are actively growing and reproducing at the same time as CWG. We will use a ‘search and destroy’ method to individually treat the pioneering CWG plants.

Established Stands

Much work has been done on restoring established stands of CWG at Grasslands National Park (NP), just over the border in Saskatchewan, CA. These efforts have found that even after seven years of repeated herbicide (glyphosate) application, CWG could be reduced to <10% cover, but it was not eliminated and the seed bank had not decreased (Ambrose and Wilson 2003, Bakker et al 2003, Wilson and Partel 2003, Hansen and Wilson 2006). This is attributed, in part, to the fact that any CWG plants that survive the herbicide treatment are released from intraspecific competition and significantly increase their seed production (Wilson and Partel 2003, Hansen and Wilson 2006).

Since CWG spreads exclusively by seed (Hansen and Wilson 2006), controlling seed production is key to controlling invasion. Several studies on the effects of clipping have also been conducted during restoration efforts at Grasslands NP. One year of clipping led to less CWG cover than 5 years of herbicide and clipping for 3 years reduced CWG cover to the same extent as herbicide for 7 years (Wilson and Partel 2003). Clipping was more consistent from year to year also, perhaps because it is easier to be consistent with a mower than with herbicide application. The total cover of native species also increased with clipping (Wilson and Partel 2003). However, the seed bank persisted for at least 3 years despite repeated clipping, but plots were small and may be influenced by adjacent CWG plants (Wilson and Partel 2003). Combining clipping with herbicide does not appear to be more effective, as clipping increased native cover in plots without herbicide, but had little effect in plots with herbicide (Wilson and Partel 2003).

The application and effectiveness of clipping is highly dependent on precipitation and timing of clipping. The effect of clipping can be magnified, and perhaps even lead to stand failure, when combined with water stress created by drought. Fortunately, at Benton Lake, much of the established CWG infestations are adjacent to road-sides, which makes mowing easier.

I. Materials and Methods

A pilot program to begin testing treatment effectiveness was started in 2008. One management unit of the refuge was chosen to treat established stands and pioneer CWG (Figure 2).

Pioneers

A portion of the pilot area was treated for pioneer plants by two field technicians in one afternoon with backpack sprayers (Figure 2). The technicians walked back and forth across the treatment area systematically spraying pioneer plants. Glyphosate (1:2 mix of glyphosate:water) was applied to individual plants at a rate of 1.1 kg active ingredient/ha (Wilson and Partel 2003). We added a dye to make it easier to track coverage. Herbicide was applied at the 3-4 leaf stage in early June (06-05-08). One technician used a 5 gallon bucket with the bottom cut out to test if this would be effective at reducing overspray to non-target plants.

Established Stands

Fortunately, at Benton Lake, much of the established CWG infestations are adjacent to road-sides. In the pilot area, the established CWG stands were evenly divided into 9 subplots of approximately 1 acre each. We divided the 9 plots into blocks of 3 subplots each from north to south and then randomly assigned one subplot in each block of three to either a mowing treatment, herbicide treatment or no treatment (control) (Figure 2).

Mowed subplots

We mowed CWG at the four leaf stage, just prior to seed head emergence, in late May (05-29-08). We mowed again three weeks later (06-18-08) after mowed plants had re-grown to the 3-4 leaf stage. Mowing was done initially on sub-plot 2_C with a riding lawnmower, but this proved to be slow and unnecessary. Mowing sub-plots 2A and 2B in May, and all subplots in June, was done with a bat-wing mower on the back of a tractor on the lowest setting. Each mowing event was completed in one day.

Herbicide subplots

Glyphosate (1:2 mix of glyphosate:water) was applied to individual plants at a rate of 1.1 kg active ingredient/ha from a boom sprayer attached to an ATV at the 3-4 leaf stage in late May (05-29-08). Winds were out of the southwest at 5-12mph and there was some rain within the 24 hours following treatment. Herbicide treatments were completed in one day.

Monitoring

<u>Pioneer plants</u>
We marked and photographed 5 pioneer plants treated with the bucket and 5 pioneer plants treated without the bucket at the time of treatment (Figure 2). We photographed these plants again on 10-30-08 to assess effectiveness of the spray treatment.

In addition, we walked twenty, 4m wide transects (systematically spaced every 60m) across the pioneer invasion zone (Figure 2). Transects were followed by using a GPS set at a scale of 1:1000 +/- 50. Within each transect, we counted the number of individual CWG plants. This will be revisited each year after treatment.

Established stands

To monitor the effectiveness of these treatments we randomly established two 20m x 0.1m belt transects centered on, and perpendicular to, the invasion front for each subplot (Grant et al 2004) (Figure 2). Each 0.5 x 0.1m section of the belt transect was assigned to one of three categories based on dominant vegetation (>50%): (1) native, (2) crested wheatgrass (3) other. From these we will be able to detect the spread of CWG into native prairie and/or the spread of native prairie back into the prior CWG stand. Percent cover of natives and CWG were estimated at the 0, 5, 10, 15 and 19m points along the belt transect using 1 x 0.5m frame (Daubenmire 1959). Data was collected in 2008 pre-treatment and transects will be revisited in 2009 just prior to treatment.

II. Results

Pioneer plants

Of the ten marked plants, none of the 5 treated with the bucket were completely eradicated. Whereas 4 of the 5 treated without the bucket were completely eradicated. The plants that were not completely eradicated were partially killed, but some tillers remained that set seed this year after treatment (Figure 3). This highlights the need for careful and complete herbicide application.

The bucket apparently limited the effectiveness of the spray treatment on individual plants. Furthermore, pioneers may be in clumps of two to several plants and a bucket is not big enough to encompass the clump. In addition, the bucket picks up herbicide along the inside walls, which drips as the applicant moves across the native prairie, which may negatively impact non-target plants. The bucket was also difficult to work with and put additional strain on the applicator's back.

Established stands

Mowing was effective at preventing seed production and adult plants did not appear to grow after the second mowing. The second mowing was not necessary to prevent seed set. This was apparent from an area we avoided mowing the second time in subplot 2C due to an active duck nest, and these plants grew taller, but still did not produce seed (Figure 4a). Mowing was uneven due to terrain effects, but this did not appear to affect the extent of re-growth or prevention of seed production. During reconnaissance of the treatment plots, we noticed native forbs were visibly apparent immediately after mowing (Figure 4b) and native grasses grew above the CWG later in the season (Figure 4c).

Herbicide treatment was more variable. High levels of variation in herbicide effects were visible within one week post treatment. This may have been due to problems with one of the nozzles on the ATV sprayer and winds (Figure 5a). We did try to re-spray missed areas by hand one week later. Native forbs were not as apparent in the herbicide treated areas, but blue grama was visible later in the season (Figure 5b).

Baseline monitoring data

Pioneer plants

The number of plants counted on each transect is presented in Table 1. The total area covered by the transects was 8.5 acres. If extrapolated to the entire pilot area (144 ac), there are nearly 7,700 plants.

These transects will be re-run in 2009 prior to additional treatment. By re-running the transects in 2009 in both the treated and untreated areas we will be able to assess how well spot spraying killed CWG, and also be able to estimate between year observer error in the untreated areas.

Established stands

The community-level composition data for the belt transects placed at the CWG invasion front is shown in Figure 6. The baseline percentage of each transect in CWG and native dominated communities was around 40-50% each. Other vegetation community types detected on the transects include bareground (predominantly on the CWG side) and Japanese brome (predominantly on the native prairie side).

Percent cover measured in the smaller frames is shown in Figure 7. The frame at 10m is approximately at the invasion front. As expected, the frames outside the CWG stand (0m, 5m) had primarily native and those within the stand (15m, 19m) had primarily CWG. This was true for all treatment types. This finer scale monitoring will allow us to detect any shifts away from CWG to natives before the belt transect would detect change. These will be re-run in 2009 prior to treatment.

Hardcopies of data collection sheets, spreadsheets and analysis will be filed in the biologist's office under bnl_biological_program/biotic/vegetation/ invasives/crested wheatgrass; Electronic copies of data will be stored in the same directory on the biologist's computer.

III. Discussion

We learned valuable information during the 2008 pilot year of CWG control. As expected, pioneer plants are susceptible to treatment with glyphosate. However, not all of a plant is always killed in the first year. Some tillers can survive and produce seed. This has been found in other studies at Grasslands NP where herbicide-treated tussocks still remained alive after two years and some still produced seed (Hansen and Wilson 2006). This result, in addition to existing seeds in the seed bank that are not killed by herbicide treatment, indicates that areas of pioneering CWG plants will need to be treated repeatedly to achieve control. An appropriate and achievable level of control, for example a certain number of plants per acre, has not yet been determined. In the next year or two, our monitoring results, combined with anticipated human and capital resources, should allow us to set a reasonable objective for "success" in controlling early CWG invaders.

Although the detailed monitoring transects have not been run yet to measure post-treatment effects, casual observation suggests that the mowing and herbicide treatments both had strong impacts on the established CWG stands. Mowing was successful in preventing seed emergence and further vegetative growth. We expect at least two consecutive years of mowing will be needed to see significant CWG reductions (Hansen and Wilson 2006). We were encouraged by native plants, such as green needle-grass, that we observed growing above the CWG and setting seed in 2008.

The herbicide treatments need to be more carefully applied in 2009. Judging by the dead CWG vegetation after treatment, the herbicide effectiveness was quite variable. We did see native grasses, in particular blue grama, growing and setting seed among the dead CWG. The success of this treatment, to be assessed in 2009, will be key in determining the next steps. If native species are colonizing the treatment area on their own, we may switch to spot spraying of CWG. If not, we will completely treat the area again with glyphosate and plan to seed with native species once CWG cover has been reduced to <10%.

Experience of refuge staff on previous refuges suggests that spraying CWG earlier (late Apr-early May), immediately after green-up, may be effective in killing CWG, but allows for native plants to emerge without needing to re-seed. We will try this treatment on approximately one-third of each control plot from 2008.

IV. Literature citations

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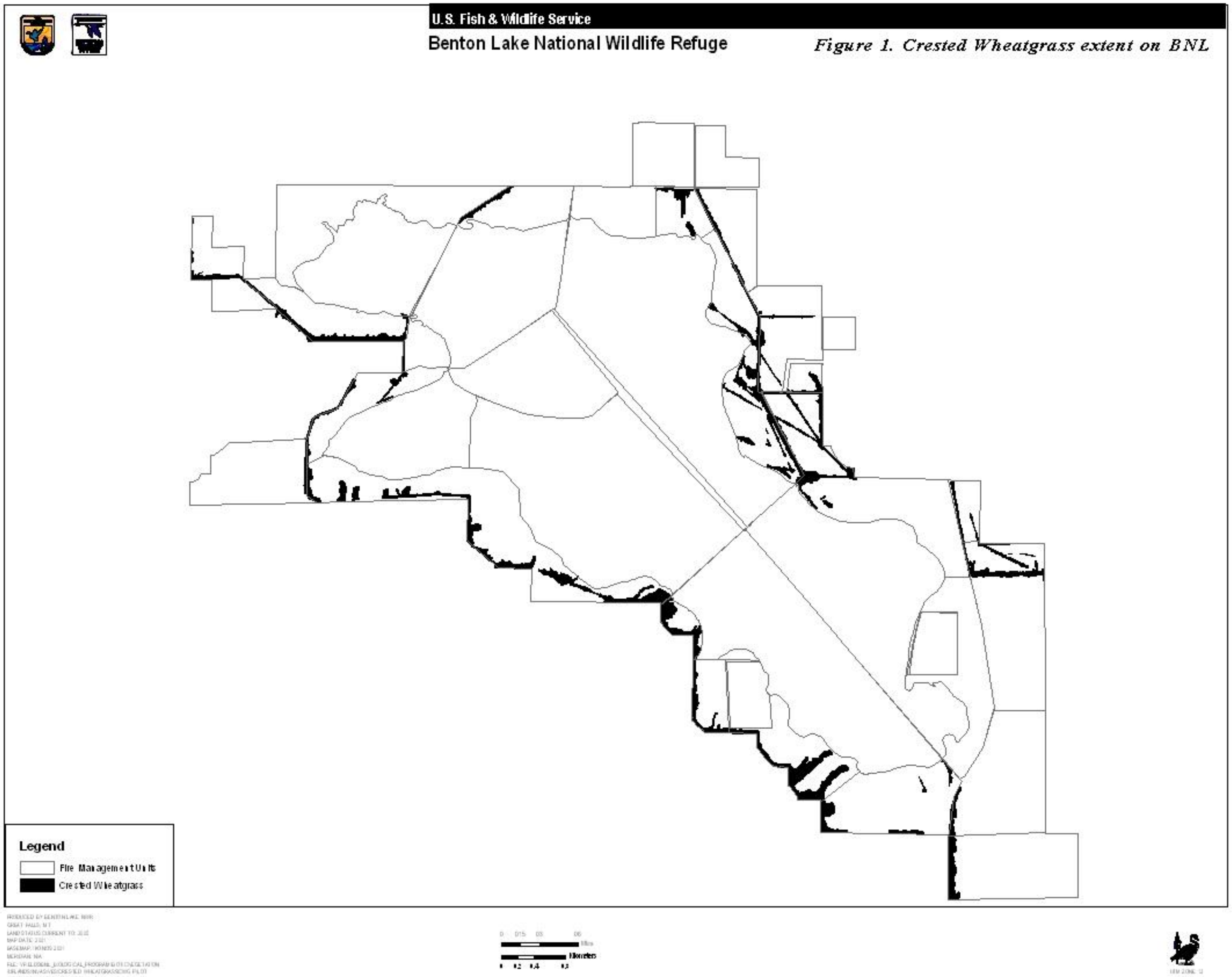


Figure 1. Crested Wheatgrass extent on BNL

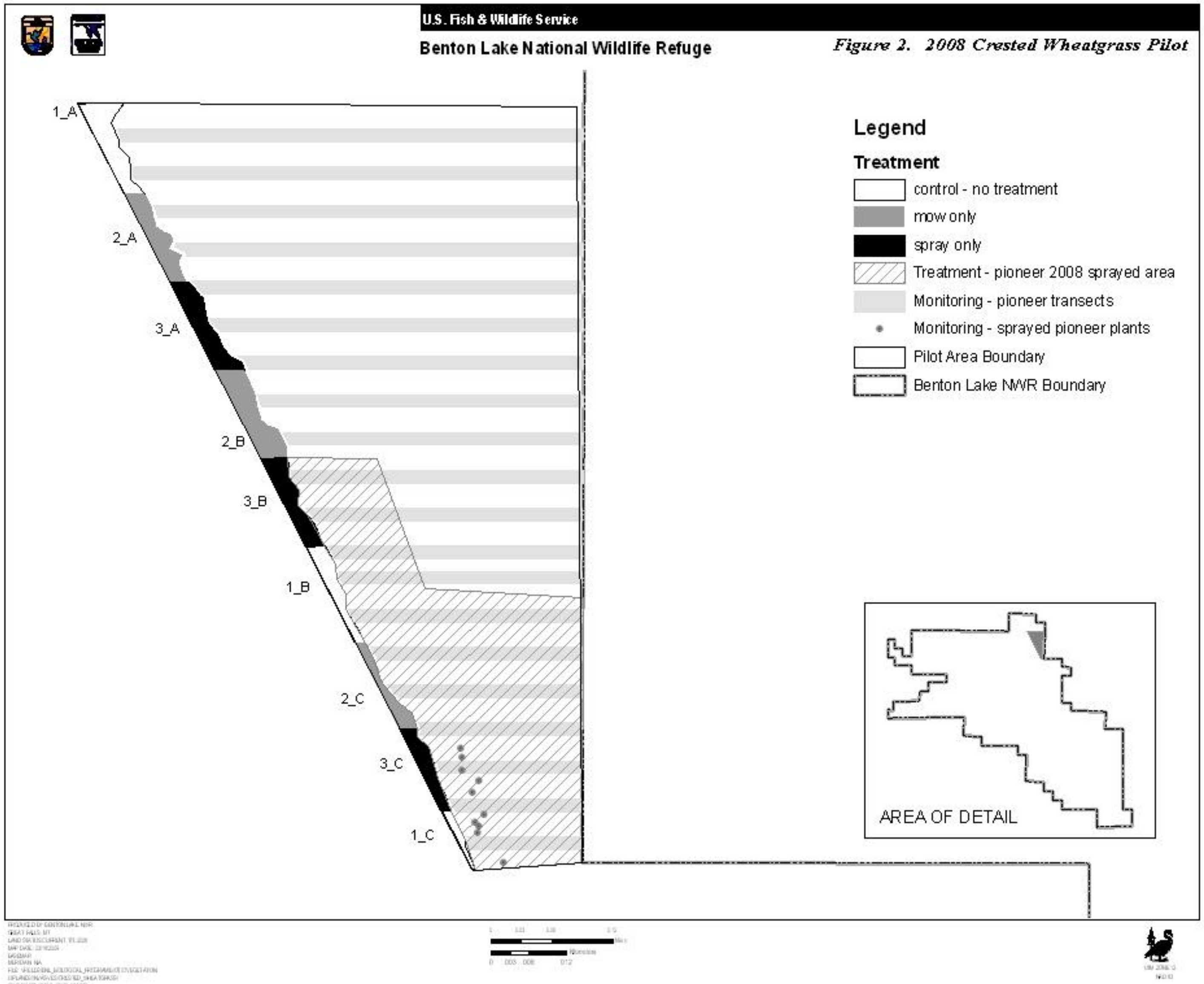

U.S. Fish & Wildlife Service
Benton Lake National Wildlife Refuge
Figure 2. 2008 Crested Wheatgrass Pilot
1_A
2_A
3_A
2_B
3_B
1_B
2_C
3_C
1_C
Legend
Treatment
control - no treatment
mow only
spray only
Treatment - pioneer 2008 sprayed area
Monitoring - pioneer transects
Monitoring - sprayed pioneer plants
Pilot Area Boundary
Benton Lake NWR Boundary
AREA OF DETAIL

Figure 3a. Pioneer plant immediately post treatment (left) and five months later (right). The plant appears to have been completely killed.

Figure 3b. Pioneer plant immediately post treatment (left) and five months later (right). Several tillers on this plant survived the treatment and set seed.

Figure 4a. Mowing either once or twice successfully prevented seed production. However, the second mowing (right half) preventedadditional vegetative growth, which should put more stress on root reserves and further weaken the plants.

Figure 4b. Native forbs became obvious after mowing treatment.

Figure 4c. Native plants, such as green needlegrass, grew above the mowed CWG and set seed.

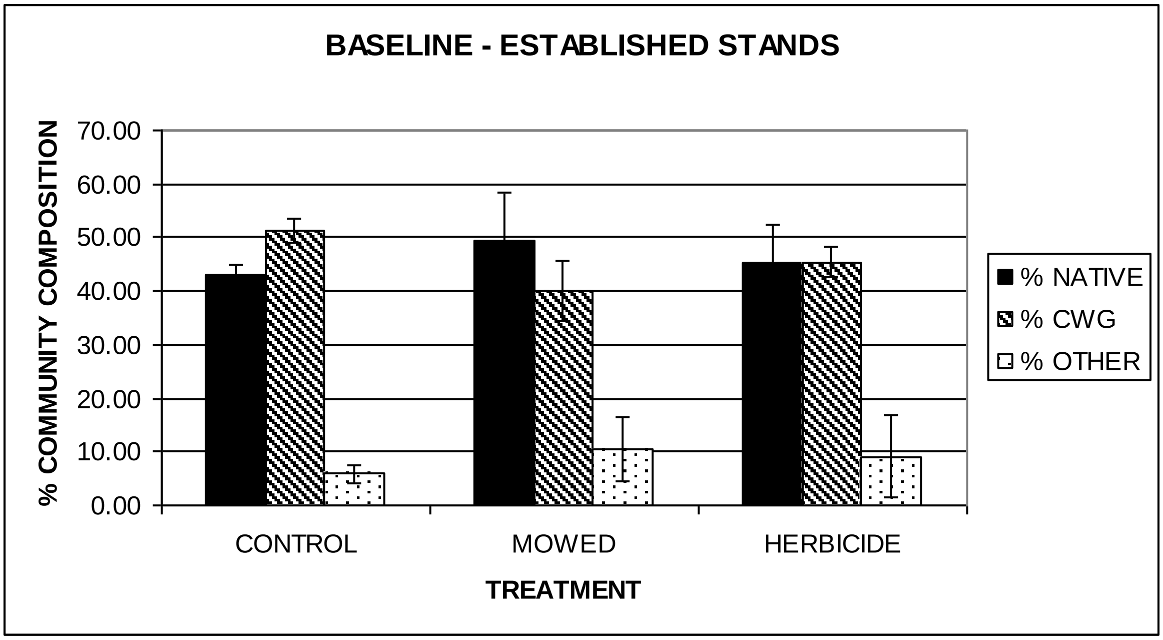
Figure 5a. Herbicide effectives was patchy as evidenced by the alternating areas of green and brown.

Figure 5b. Native grasses, such as blue grama, were Present in herbicide treated areas later in the summer.

Table 1. Number of pioneer CWG plants per transect within the pilot treatment area. If extrapolated to the entire pilot area, an estimated 7697 CWG plants are present.

Date	5/29/2008	
Transect#	CWG count	Comments
1	26	
2	1	
3	6	
4	0	
5	2	
6	5	
7	51	mostly by shelterbelt
8	68	
9	26	
10	46	
11	20	
12	7	
13	20	
14	0	
15	134	
16	24	
17	1	
18	0	
19	5	
20	7	
Total	449	
Estimate for total pilot area		7697.14

Figure 6. Baseline vegetation composition of belt transects placed at the invasion front for two treatments and control.



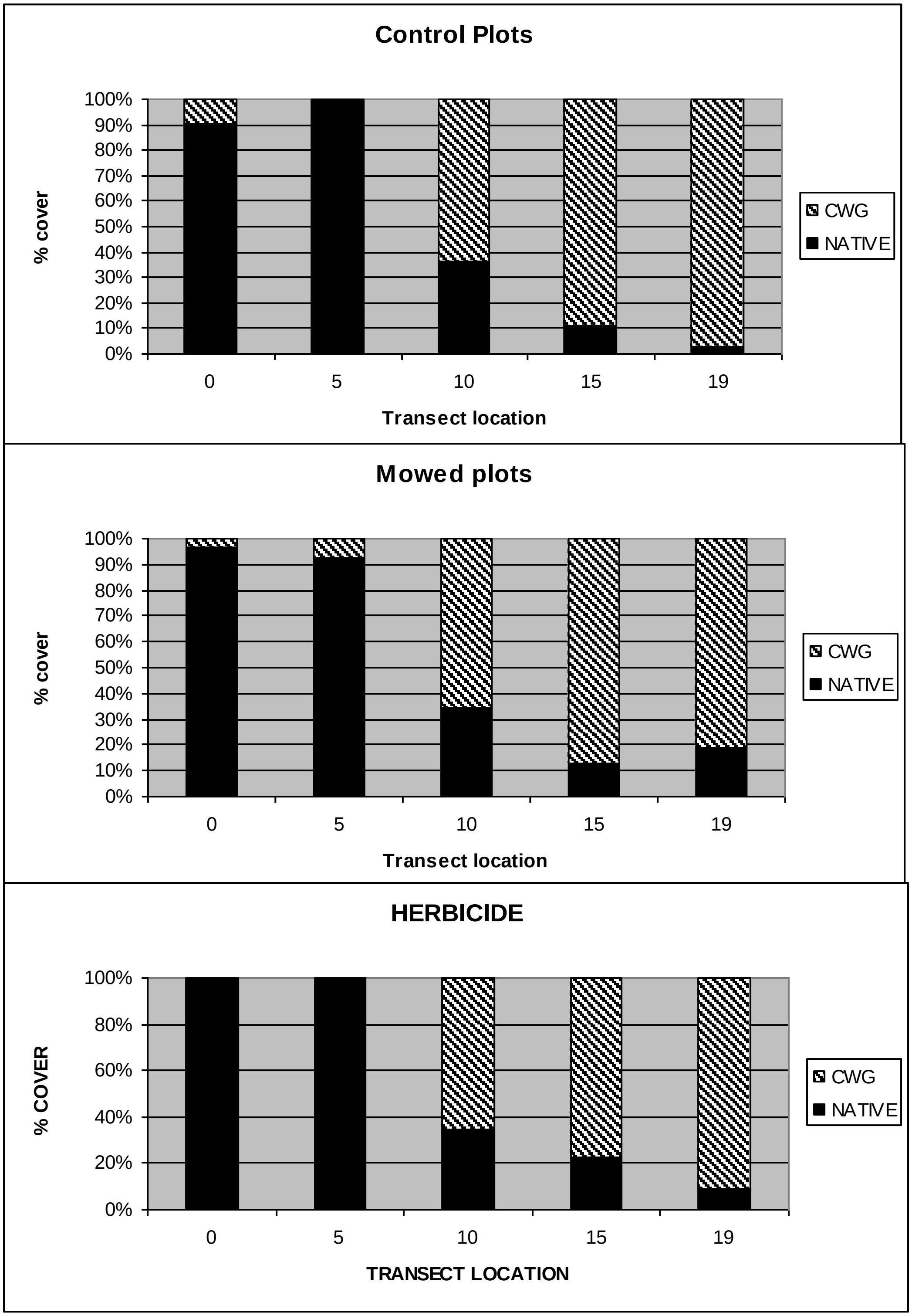


Figure 7. Percent canopy cover (out of 100) for native plants versus CWG at 5 locations along the transects. The invasion front is approximately at 10m.